all the "meres" are visible. Having submitted the work, Mr. Harrison tells us, to gentlemen of scientific repute, and being encouraged by their favourable criticisms, he has concluded, if a sufficient number of subscriptions can be obtained, to publish a work under the title of "Telescopic pictures of the Moon," in oil colour chromos (the only medium for facsimile reproduction of paintings) 2 feet in size, with an image of 18 inches in diameter, in six progressive pictures of the following phases:—1. Three days old crescent, terminator at Mount Glacier. 2. Five days old, terminator at the crater Katharina. 3. Seven days old, or first quarter. 4. Nine days old, sunrise at the crater Copernicus. 5. Full moon; and 6. Last quarter. An outline drawing with letter-press description, bearing the names and sizes of all objects, will accompany the work, which will be completed in about a year from the time the first phase has been issued, and will be furnished to subscribers complete for 30 dols., or 5 dols. for each plate. The description will appear gratuitously with the last issue. Subscribers should send full name and address to Henry Harrison, P.O. Box, 179, Jersey City, New Jersey.

A VERY successful experiment has been made at Lockport, New York State, in supplying heat to houses by steam supplied from a central station, in much the same way as gas is supplied. The experimental works in Lockport were commenced last year, and during the late winter about 200 houses in the city were heated from the central supply, through about three miles of piping, radiating from the boiler-house, containing two boilers 16 feet by 5 feet, and one boiler 8 feet by 8 feet. These boilers were, during the winter, fired to a pressure of 35 lb. to the inch, with a consumption of 4 tons of anthracite, costing 4½ dols. a ton during the summer, but one boiler is fired consuming a ton and a half of anthracite in twenty-four hours, and a pressure of 25 lb. per inch maintained. The boiler pressure of 35 lb. in winter, and 25 lb. in summer, is maintained through the entire length of the three miles of piping up to the points of consumption, where there is a cut-off under the control of the consumers. The distribution of heat in the apartments is by means of radiators, consisting of 1 inch pipes 30 inches long, placed vertically either in a circle or as a double row, and connected together, top and bottom, with an outlet pipe for the condensed water, which escapes at a temperature a little below boiling, and is sufficient for all the domestic purposes of the house, or is used as accessory heating power for horticultural and other purposes. The steam has also been applied at a distance of over half a mile from the boilers for motive power, and two steam-engines of ten and fourteen horse-power are worked from the boilers at a distance of half a mile, with but a slightly increased consumption of fuel. The laid on steam is being also used for cooking purposes, for boiling, and even baking, and Mr. G. Maur, F.G.S., who describes the system, witnessed in a house three quarters of a mile from the boilers, a bucket of cold water raised to boiler heat in three minutes by the passage of the steam through a perforated nozzle plunged in the bucket. The operations of the Heating Company have been up to the present time of an experimental character, and from the 200 houses already supplied with the heating connection, the actual cost of the coal that would have been used for heating has been provisionally received in payment, and the amount has left a wide margin over the working expenses, though the company's operations at present cover but a small portion of the area for which they have provided plant.

THE additions to the Zoological Society's Gardens during the past week include two Mandrills (*Cynocephalus mormon*), an Ocellated Monitor (*Monitor ocellatus*) from West Africa, presented by Mr. G. H. Garrett; two Greater Spotted Woodpeckers (*Picus major*), British Isles, presented by Mr. J. A. Cooper; a Greater Sulphur-crested Cockatoo (*Cacatua galerita*) from Australia, presented by Mr. N. Portocalis; a Horned Lizard (*Phrynosoma cornutum*) from Texas, presented by Mr. J. C. Witte; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Mr. W. W. Spicer; two Indree Owls (*Syrnium indranee*) from Ceylon, deposited; two Common Seals (*Phoca vitulina*) from British seas, a White-fronted Amazon (*Chrysotis leucocephala*) from Cuba, two Oyster Catchers (*Hæmatopus ostralegus*), British Isles, purchased; two Horned Tragopans (*Ceriornis satyra*), an Impeyan Pheasant (*Lophophorus impeyanus*), bred in the Gardens.

THE ROYAL OBSERVATORY

THE annual visitation of the Royal Observatory took place on Saturday week, when the Astronomer-Royal read his Report, which refers to the year ending May 21.

The Report on the buildings and grounds, movable property, manuscripts, library, astronomical instruments, &c., is, as usual, satisfactory. The new railway through the town of Greenwich has apparently had no effect at the observatory.

The usual varied astronomical observations have been carried on with the usual diligence, the advantageous observation of the small planets being, however, limited by the want of ephemerides.

To facilitate the observations of stars, a new working catalogue has been prepared, in which are included all stars down to the third magnitude, stars down to the fifth magnitude which have not been observed in the last two catalogues, and a list of 258 stars of about the sixth magnitude of which the places are required for the United States Coast Survey. The whole number of stars in the new working list is about 2,500. An extensive series of observations was made, during the autumn, of about seventy stars, at the request of Mr. Gill, for comparison with Mars, Ariadne, and Melpomene.

Among the observations made we may mention 3,970 transits, the separate limbs being counted as separate observations, and 3,824 circle observations, each requiring a separate reading of the six microscope micrometers. Twenty-nine sketches of Mars were obtained with the great equatorial near his opposition, forming a complete record of the appearances of that planet during the entire rotation. Preparations were made for observing the Transit of Mercury on May 6, but owing to the unfavourable state of the weather no result of importance was obtained. A great amount of work has been done in the reaction of astrononomical observations.

The computations for the "Nine-Year Catalogue" of 2,263 stars, including some supplementary investigations, were completed in the course of 1877, and the introduction has been prepared and sent to the printer. The catalogue is drawn up in the same form as previous catalogues, the only noteworthy alterations being the addition of another decimal place to the R.A.'s and annual precessions in R.A., which are carried to 0s·001 and 0s·0001 respectively. The right ascensions are thus made to correspond more nearly with the north polar distances as regards the degree of accuracy exhibited.

During the past year the sun's chromosphere has been examined with the spectroscope on seventy-nine days (on two of these through part of the circumference only); prominences were seen on fifty-eight days. All the observations, however, tend to show that the solar prominences have been few in number and insignificant in size for many months.

All observations with the spectroscope have been completely reduced; the position-angles of prominences being converted into heliographic N.P.D.; and the displacements of lines in the spectra of stars being reduced so as to exhibit the concluded motion in miles per second, after applying a correction for the earth's motion.

The areas, position-angles, and distances from the sun's centre, of sun-spots and faculæ, have been measured to the end of 1877, and in duplicate July 5, 1877.

The correction of the position-angles and distances for the effects of refraction and distortion, and their conversion into heliographic longitude and latitude, have been pushed forward as rapidly as circumstances would admit after the measurements had been completed. As there is a considerable accumulation of arrears since 1873, which will require many months for their reduction, it has seemed desirable to commence with the year 1876, with the view of including in the volume for 1876 the

complete deductions from the measures of sun-spots and faculæ in that year, if they can be prepared for press in time, leaving the complete results for the years 1873 to 1875 to be included in the next volume; the areas, as distinct from positions, having been already printed in the volumes for 1874 and 1875.

The usual magnetical and meteorological observations have been carried on, and considerable progress made with their reduction.

The following are the principal results for magnetic elements in the year 1877 :—

Approximate mean westerly declination 18° 57′.

Mean horizontal force . . { 3·901 (in English units). 1·799 (in metric units).

Mean dip . . . . { 67 38 46 (by 9-inch needles). 67 39 54 (by 6-inch needles). 67 40 40 (by 3-inch needles).

Under the head of Extraneous Work, information is given as to the reduction of the Transit of Venus observations.

At the date of the last Report the determination of the longitudes of the British stations was not quite complete (that of Kerguelen being then imperfect). But, under a demand from the House of Commons, a strong effort was made to finish all introductory calculations, and to effect computations of solar parallax by comparing all eye-observations of ingress of Venus among themselves, and all eye-observations of egress of Venus among themselves. The different stages of phenomena at the ingress were discriminated by Capt. Tupman with great care, and Sir George Airy believes with great general success, although Capt. Tupman himself has been induced lately to modify his interpretation of the observers' language in one or two instances. Finally, a report was made to the Government on July 5, giving as the mean result for mean solar parallax 8″·76, the results from ingress and from egress, however, differing to the extent of 0″·11. A more complete calculation by the Astronomer-Royal, including in one series the observations both at ingress and at egress, and recognising the possible errors of R.A. and N.P.D., gave sensibly the same mean result for parallax. This is liable to no error except from the interpretation of observers' language. All has subsequently been re-examined by Capt. Tupman; different interpretations have, in a few instances, been put on the records; several observations from colonial stations have been combined; instead of using different phases in the observations (both of ingress and of egress), attempts have been made to ascertain the one phase of "contact of limbs;" the notes of a few unpractised observers have been rejected, and the result for parallax has been increased to 8″·82 or 8″·83.

The numerous photographs taken at the various stations had been carefully measured by Mr. Burton, and have since been re-measured by Capt. Tupman; and (by photographs of Mr. De la Rue's scale of equal parts) the measure of photographic distortion had been well ascertained. But the results from photography have disappointed Sir George Airy much. The failure has arisen perhaps sometimes from irregularity of limb, or from atmospheric distortion, but more frequently from faintness and from want of clear definition. Many photographs which to the eye appeared good, lost all strength and sharpness when placed under the measuring microscope. It was once remarked to Sir George Airy, "You might as well try to measure the zodiacal light." A final result, 8″·17, the report states, was obtained from Mr. Burton's measures, and 8″·08 from Capt. Tupman's.

The Report next alludes to the progress made in the numerical lunar theory. The developments of the effect of every possible error (expressed as a symbolical variation) in the co-efficients and arguments of the assumed lunar ordinates upon every term in the three fundamental expansions of—(1) Areas in the ecliptic, (2) Radial forces in the ecliptic, (3) Forces normal to the ecliptic—have been computed and printed. The corresponding solar perturbing forces have been computed entirely for the first of these (care being taken to extend the decimal calculation further for those terms whose effect may probably be increased in solution of the equations, a process in which many figures are almost necessarily wasted), and partially for the second and third. Until all have been completed the Astronomer-Royal cannot draw any positive inference from the comparison of these terms with those of the ordinate expansions; but a cursory collation of those relating to the areas led him to suppose that there might be some error in the computations of the annual equation and related terms. A most jealous re-examination has, however, detected nothing, and has confirmed Sir George Airy's belief in the general accuracy of the numerical computations.

Finally, Sir George Airy strongly urges upon the Board the necessity for the erection of a separate room for the library of the Observatory.

COSMICAL RESULTS OF THE MODERN HEAT THEORY

IN the *Sitzungsberichte der Wiener Akademie der Wissenschaften*, Herr J. Loschmidt has published a treatise on the equilibrium of temperature in a system of heavenly bodies with regard to gravitation, from which we note the following highly interesting details :—"Sir W. Thomson and Clausius simultaneously,[1] drew from their researches the surprising conclusion that the whole universe at some definite period, however remote, would infallibly come to an end. First, all ponderous masses in the universe will eventually have united to one enormous heavenly body; and secondly, upon this body all visible motion will have ceased, all forces having changed to mere molecular motion, which in the shape of heat of universally uniform temperature will be spread in this mass. This state of general death will then last eternally." Herr Loschmidt, in the course of his researches, has arrived at widely different conclusions. He begins by adopting the general view that the sun is in a state of slow progression of cooling, and that the time will unavoidably arrive when his surface will have solidified, long after all his planets have fallen in upon him, and after his upper and partly also his lower strata have assumed very nearly the temperature of the surrounding universal space. But granting that thus a period of rest and death will have arrived for our solar system, Herr Loschmidt maintains, at the same time, that this period cannot be of unlimited duration; the state of things just described can, according to his views, not be a state of equilibrium. "The previous liquid state of the sun has caused a continued mixture of the warmer parts near the centre with the colder ones near the surface. Thus, however, the equilibrium of temperature, which requires a certain increase of temperature towards the interior, was rendered impossible. At the moment of solidification of the external layers the deeper ones will be far colder than the theory of the state of equilibrium demands. Because, according to this theory, the surface should have the temperature of universal space (about − 140° C. according to Pouillet), but this temperature should rapidly increase towards the interior, reaching at the centre the enormous figure of 250,000,000° C. And it is just because at the moment of the beginning of solidification of the sun no such distribution of temperature took place in the interior, that the state above referred to cannot be of eternal duration. During an extremely long period, in spite of the low temperature of his surface, the solidifying sun will constantly absorb radiant heat from the store in the universe and will concentrate this heat in his interior. We suppose, for a moment, that it would be physically possible that this process of absorption is carried on to the end without the inclosed and dissociated gases in the interior breaking through the solidified surface or crust on account of their enormous tension. We then calculate the amount of heat accumulated in the end and find that it would easily suffice to raise the entire solar mass to $\frac{2}{3}$ths of that temperature which the state of equilibrium demands at the centre, viz., to 100,000,000° C. This figure is raised if the average molecule of the solar mass, instead of being supposed to be of the density of oxygen, is taken to be of the density of carbonate of lime; in that case it would be 125,000,000° C. We may compare these results to the quantity of heat which was produced during the condensation of the solar system from the cosmical nebula, according to the theory of Laplace and Kant. Helmholtz has calculated that the heat thus generated would suffice to raise the solar mass to a temperature of 28,611,000° C., if it is supposed to have the heat capacity of water. If, instead of water, other substances are taken as starting points, this temperature is considerably raised; so in the case of carbonate of lime or silicic acid, the heat capacity of which is 0·2, the resulting temperature would be 140,000,000° C.

"The close correspondence of both amounts speaks in favour of a *periodicity in the history of solar systems*. In the first portion of its cosmical period the dark solidified body absorbs heat

[1] [Clausius *verified* Thomson's statements about dissipation just as he *verified* (after experiment had proved it) J. Thomson's statement of the lowering of the freezing-point of water by pressure. Some Germans still call this "simultaneous discovery." Helmholtz, at least, does not.—ED.]